CHAPTER 4. HIGHER EDUCATION

INSTITUTIONS

In contrast to the relatively recent development of higher education institutions in other Asian countries, Japan greatly expanded its institutions of higher education in the 1950s. By 1955, public institutions, including the national universities (totally funded by the national government), and local institutions (funded by the prefectures and municipal governments), numbered over 100. The total number of public institutions has not increased significantly since then. An additional 25 national and 15 local universities have opened in the last 40 years. In contrast, the number of private institutions has increased rapidly over the last few decades, growing to more than 400 in 1995, and representing approximately 75 percent of all higher education institutions (Monbusho, 1995a).

The largest numbers of graduate enrollments in Japan are in private schools, but national universities still dominate in the production of doctoral natural science and engineering (NS&E) degrees. About 30 of these national universities are considered research universities. The national universities account for about one-half of the social science doctoral degrees and 85 percent of the doctoral degrees in engineering, natural sciences, and agricultural sciences (Monbusho, 1995c). In the United States, research universities, which number about 88, also dominate in advanced degrees in science and engineering.[15] In 1993, students in the United States earned 75–85 percent of their master's and doctoral degrees in science and engineering at research universities (NSB, 1996).

TRENDS IN UNDERGRADUATE EDUCATION

ASSOCIATE DEGREES

In Japan, associate level programs are small compared with 4-year college and university programs. In 1994, student enrollment at the associate level numbered 550,000 compared with 2.2 million at the bachelor's level. Engineering students at the associate level in Japan attend two types of institutions: 5-year technical colleges or 3-year junior colleges. In 1994, these institutions each produced about 10,000 engineering degrees. Entrance level and characteristics of these institutions differ considerably. The far more numerous junior colleges (548) are predominantly private institutions with an enrollment that is 90 percent female; only 4 percent of their earned degrees are in engineering. The smaller number of technical colleges (62) are public institutions with an enrollment that is 80 percent male. Students enroll in 5-year technical colleges following completion of compulsory education, 9th grade.[16] The programs of technical colleges are aimed at training technicians and practical engineers.[17] In contrast, Japanese students enter junior colleges after completion of upper-secondary education, 12th grade.

Engineering departments in junior colleges, traditionally all male departments, sharply increased their rate of female enrollment between 1975 and 1990. Young women now comprise approximately 30 percent of the engineering student body at the junior college level, mainly in electrical and communications engineering and applied chemistry. While the number and percentage of females entering associate level engineering programs in junior colleges is increasing, it is from a small base (table 8). In addition, the Monbusho annual survey of education shows that the number of males entering such programs declined about 25 percent from 1975–93.

Recent declines may be influenced by demographic changes, as well as the decline in the 18-year-old population in Japan. With a declining college-age population, the number of 18-year-olds entering the university is dropping, down from a peak of 2.05 million in 1992 to an estimated 1.5 million in 2000. This demographic trend will continue until at least 2010. In con-

[15] According to the Carnegie classification, U.S. research universities offer a full range of baccalaureate programs, are committed to graduate education through the doctorate degree, and give high priority to research. Research I universities receive at least $40 million annually in federal support and award at least 50 doctoral degrees. Research II universities meet similar conditions, but receive between $15.5 million and $40 million annually in federal support.

[16] Education in Japan becomes quite stratified at the upper secondary level, separating those who will go to junior colleges and universities from those who will enter vocational schools and technical colleges.

[17] Students in technical colleges may transfer to the upper division at the university where they would have two more years of study in order to graduate with a bachelor's degree.

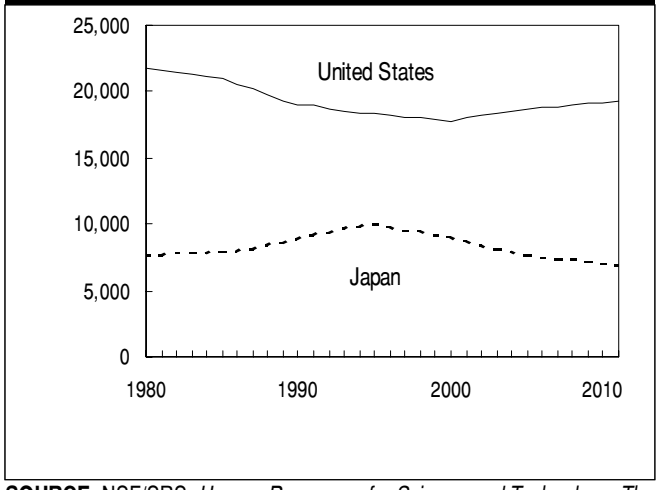
Table 8. Female enrollments in engineering at the junior college level

Year	Total	Female	
	[Number]	[Number]	[Percent]
1975	23,335	885	3.8%
1985	19,787	3,028	15.3
1990	24,843	7,272	29.3
1991	24,927	7,599	30.5
1992	24,794	7,718	31.1
1993	23,993	7,285	30.4

SOURCE: Government of Japan, Monbusho Survey of Education, Annual Series.

trast, in the United States, the college-age population declined earlier, starting in 1985, and it will continue to decline until the year 2000 (figure 19).

Figure 19. Population of 20- to 24-year-olds in Japan and the United States: 1980–2010



SOURCE: NSF/SRS, *Human Resources for Science and Technology: The Asian Region,* NSF 93-303, Washington, DC: NSF.

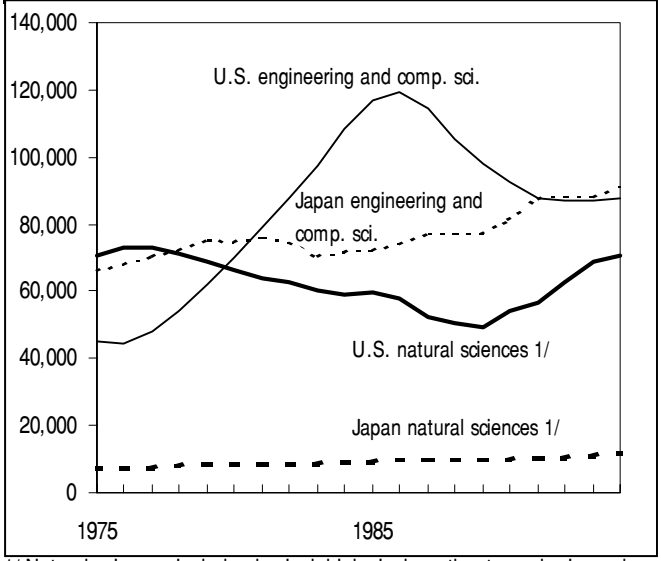
In the United States, most states have junior college courses, which will transfer from one institution to another within the state system. Taking and transferring courses are the *modus operandi* for the majority of students in the United States at two-year level institutions; only about 9 percent of those enrolled complete a 2–3-year program of studies and obtain a certificate of associate degree. In 1993, only 2,500 students completed associate degrees in engineering in U.S. higher education; another 40,000 earned engineering technology degrees. Transferring from technical colleges and junior colleges to universities in Japan, however, is not as prevalent as it is in the United States. In Japan, students in technical colleges "may" transfer to the upper-division at the university where they would have 2 more years of study in order to graduate with a bachelor's degree, but transferring is not the norm.

Bachelor's Degrees

Compared with the United States, a significantly higher proportion of Japan's undergraduate degrees are earned in engineering. Japanese undergraduate students earn 20 percent of their degrees in engineering fields,[18] far greater than the 5 percent of engineering undergraduate degrees earned in the United States. This concentration on engineering is partly explained by the greater number of engineering jobs in the labor market compared with the United States. (See Chapter 3 on international comparisons of scientists and engineers in the labor force.)

Differences in taxonomy, however, also partly explain the higher proportion of engineering majors. In Japan, engineering departments subsume computer science and also extend, to a smaller extent, to some applied fields of the natural sciences. For example, in Japan, solid-state physics is included in engineering; in U.S. universities, professors of solid-state physics are on faculties of the natural sciences. Given these differences in taxonomy, an approximate comparison of

Figure 20. B.S. degrees: 1975–94



1/ Natural sciences include physical, biological, earth, atmospheric, and oceanographic sciences.

See appendix table A-16.

[18] Japan's percentage is similar to the proportion of engineering degrees in Singapore, Korea, and Taiwan. Only China has a considerably higher concentration on engineering: 40 percent of Chinese undergraduates study engineering (NSF, 1993).

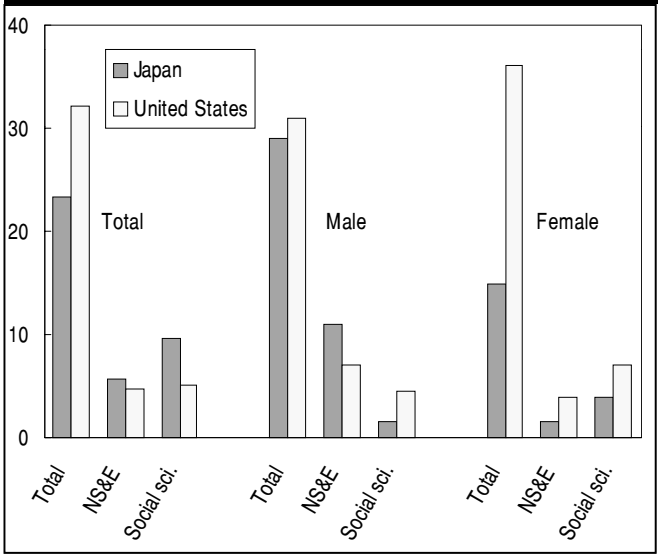
degrees is shown in figure 20 by adding computer science and engineering degrees in the U.S. data.[19] U.S. combined degrees in these fields grew rapidly from 1975–86, declined until 1991, and subsequently leveled off. The decline after 1986 is largely due to demographics and the apparent waning interest in computer science degrees at the undergraduate level. In the last decade, the number of Japan's degrees in computer science and engineering grew at an average annual rate of about 2 percent. By 1994, with roughly one-half the population, Japan produced more engineering and computer science degrees at the undergraduate level than the United States.

In contrast, relatively few degrees are earned in natural science departments in Japan, compared with the United States (even given that some degrees in applied science fields are counted within engineering). Only 3.5 percent of undergraduate degrees in Japan are earned in natural sciences (physical, environmental, and biological sciences), and even fewer, 2.9 percent, are obtained in agricultural sciences Monbusho, 1995b). In the United States, 9.3 percent of all undergraduate degrees are earned in the natural sciences, and 1.1 percent are earned in agricultural sciences (table A-16). This low percentage of earned degrees in the natural sciences reflects the relatively minimal role of Japanese universities in fundamental scientific discovery.

Because of significant taxonomy differences, only aggregated comparisons are made on the proportion of 22-year-olds with NS&E degrees, with differences by gender (figure 21). Ten percent of Japanese males of this age earn university degrees in a field of natural sciences or engineering; about one-tenth that amount, or 1 percent, of the Japanese female population, earn such degrees. In the United States, 6.8 percent of the male 22-year-old population earn a university degree in a field of natural sciences or engineering. About one-half that amount, or 3.6 percent, of the female population earn such degrees.

Japan and the United States have a similar concentration in particular engineering specialties at the undergraduate level, with some minor differences. The largest engineering departments in both countries are in electrical and computer engineering, as well as in

Figure 21. First university degrees as a proportion of the 22-year-old population: 1994



KEY: NS&E = Natural sciences and engineering.

SOURCE: National Science Foundation/SRS; table A-17.

mechanical, civil, and chemical engineering. Japan has a slightly higher concentration of students in chemical and civil engineering fields, and a slightly lower concentration of students in aeronautical and mechanical engineering fields than the United States (table 9).

Table 9. First university engineering degrees by field of study: 1994

Field of study	Japan 1/		United States	
	[Number]	[Percent]	[Number]	[Percent]
Total	91,184	100.0%	63,012	100.0%
Aeronautical/astronautical	776	0.9	2,330	3.7
Chemical	10,335	11.3	5,636	8.9
Civil	18,015	19.8	10,603	16.8
Electrical and computer	27,346	30.0	18,241	28.9
Industrial	4,757	5.2	3,453	5.6
Mechanical	18,664	20.5	15,297	24.3
Materials/metallurgy	1,125	1.2	1,106	1.8
Other	10,166	11.1	6,346	10.1

1/ Computer science is included within engineering departments in Japan. See appendix table A-16.

SOURCES: National Science Foundation, SRS, *Science and Engineering Degrees 1966–94* , NSF 96-321 (Arlington, VA, 1996); and Monbusho, Basic Education Survey, 1995.

[19] Because the numbers associated with solid-state physics in Japan are so small, these degrees were not reclassified here.

Japanese national educational reforms at the undergraduate level are directed toward more teaching of core fundamentals and an integration with, and more equal status of, the faculties of general (first 2 years) and specialized (final 2 years) education. Within engineering, Japanese universities are combining several small engineering departments for a broader, multidisciplinary perspective. Japanese universities also are introducing undergraduate research programs similar to the undergraduate research opportunity programs in the United States.

At the graduate level, reforms are directed toward increasing the scale of programs, improving the substance by introducing more course work (similar to the U.S. system), diversifying funding sources (including joint research with industry), and enhancing mobility of scientists with fixed-term appointments (Arimoto, 1996).

Trends in Graduate Education

Graduate Enrollment

Graduate S&E programs, traditionally small in Japan, have begun to expand. To increase graduate enrollment in Japan, in the late 1980s, Monbusho began establishing new universities for graduate students only. The Japan Advanced Institute of Science and Technology, East (Ishikawa Prefecture), provides research and training in information science and materials science. The Advanced Institute of Science and Technology, Nara Prefecture, begun in 1991, focuses on research and training in information science as well as bioscience.

Since 1988, industry has been allowed to donate named grants for industry—university joint research. A few universities have taken the opportunity to pursue financial support and cooperative research with industry for innovative graduate training. For example, the Research Center for Advanced Science and Technology (RCAST), within the University of Tokyo, created four research divisions in 1988, admitting only doctoral candidates.

Based on these new graduate institutes and centers at universities, graduate student enrollment grew at an annual rate of 15 percent from 1990–95 (Monbusho, 1995b). Previously, only those going into academic careers remained in the university for doctoral training. Others had no financial incentive because starting salaries in industry were the same as for those hired at the bachelor's level (Yano, 1986). Presently, more students in Japan are going forward to earn advanced degrees in natural sciences and engineering. By 1994, the ratio of undergraduate-to-graduate enrollment in engineering was 8:1. In 1975, the ratio of undergraduate-to-graduate enrollment in this field had been 20:1 (table A-18).

In the United States, with significantly larger S&E graduate enrollment in higher education, the ratio of graduate-to-undergraduate enrollment in engineering was around 3:1 in 1994. Even with the recent expansion, in 1994 Japanese graduate enrollment in all S&E fields was 91,000 compared with 433,000 in U.S. universities. Particularly small are Japanese graduate programs in the natural sciences—about one-tenth the size of those of the United States (12,000 versus 120,000 graduate students) (table A-18). In contrast, in engineering Japan has comparable enrollment in graduate programs to the United States (relative to the size of its population). In the United States, after a decade-long steady increase, graduate enrollment in S&E fields at universities declined in 1994, mainly as a result of the decline in the number of foreign graduate students in engineering both in 1993 and again in 1994 (National Science Board, 1996).

One educational policy goal in Japan is to double the number of graduate students by the year 2000, that is, from approximately 138,000 graduate students in 1994 to 277,000 graduate students in the year 2000. Such doubling would require sustaining a 12-percent annual growth rate in the number of students entering advanced degree programs. From 1990–94, the annual rate of increase was around 12 percent. Doubling the number of graduate students appears possible if all the attractions to advanced degree programs in universities continued: increasing financial support to graduate students, more exciting research at universities, and availability of state-of-the-art facilities.

A large uncertainty for the continued expansion of graduate programs is when the long economic recession will end, and thus, enable Japanese industry to begin to hire those with advanced S&E degrees. Even without doubling the number by the year 2000, the rising participation rate in graduate-level programs will create a demand for more professors at this level. The decline in the college-age population will contribute to a shift in professors from undergraduate to graduate programs.

Advanced Degrees

Since 1985, Japan's rate of growth in the number of degrees earned in natural sciences and engineering has been more than twice as high at the master's level than at the bachelor's level. Doctoral degrees began increasing a few years later (figure 22).

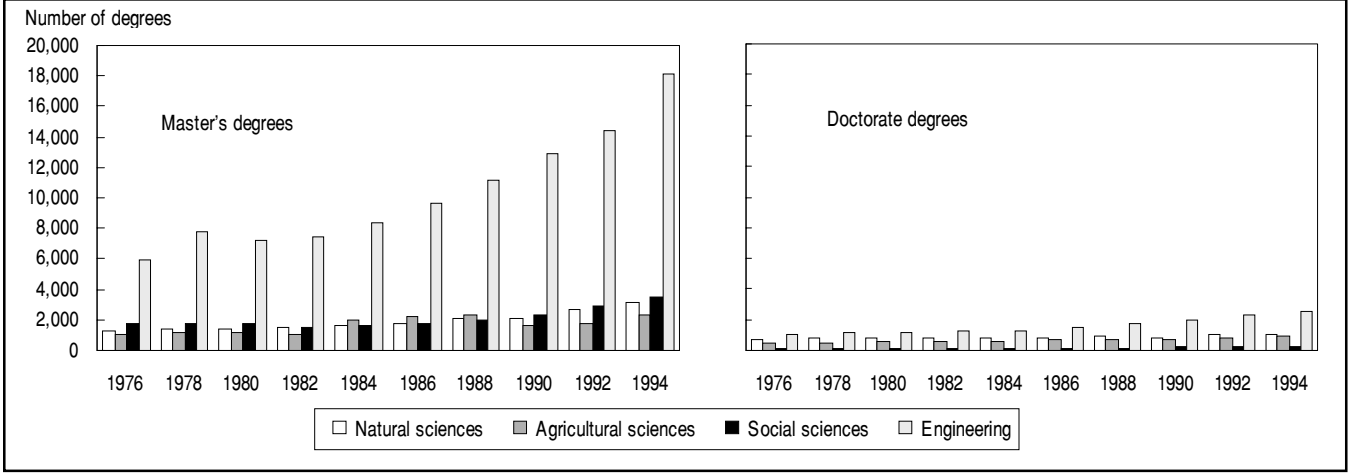
The number of graduate degrees in science and engineering is considerably larger in the United States than in Japan (figure 23).

From 1987–92, engineering doctoral degrees in Japan grew at the rate of 6.4 percent a year, and natural science doctoral degrees grew at the rate of almost 5 percent annually in the 1990s (figure 24).

Since this expansion is from a low base, however, the ratio of doctoral recipients to the general population is still relatively low in Japan. In 1994, 0.26 percent of the 29-year-old population had earned a doctoral degree in the natural sciences or engineering, compared with 0.50 percent of the same population in the United States[20] (table A-21).

Until recently, most doctorates in the natural sciences and engineering in Japan were earned by industrial researchers in Japanese companies. These degrees are awarded by the employees' former university, usually after many years of research in industrial laboratories. No matriculation is necessary, only submission of a dissertation. Until the 1990s, these doctorates, called thesis doctorates, or *ronbun hakase*, represented the majority of engineering doctoral degrees from national universities. In 1986, *ronbon hakase* represented two-thirds of all doctoral engineering degrees and more than 40 percent of all natural science degrees. With the expansion of university-based doctoral programs, however, the proportion of these degrees earned is decreasing. From 1986–94, doctoral degrees earned within Japanese universities increased 5 percent annually in the natural sciences[21] and 13 percent annually in engineering. Thesis doctorates in science and engineering grew at a much smaller rate during this same time period. By 1994, more doctoral engineering degrees were earned for research within university laboratories (53 percent) than industrial research laboratories (47 percent) (figure 25 and table A-20).

Figure 22. Graduate S&E degrees in Japan

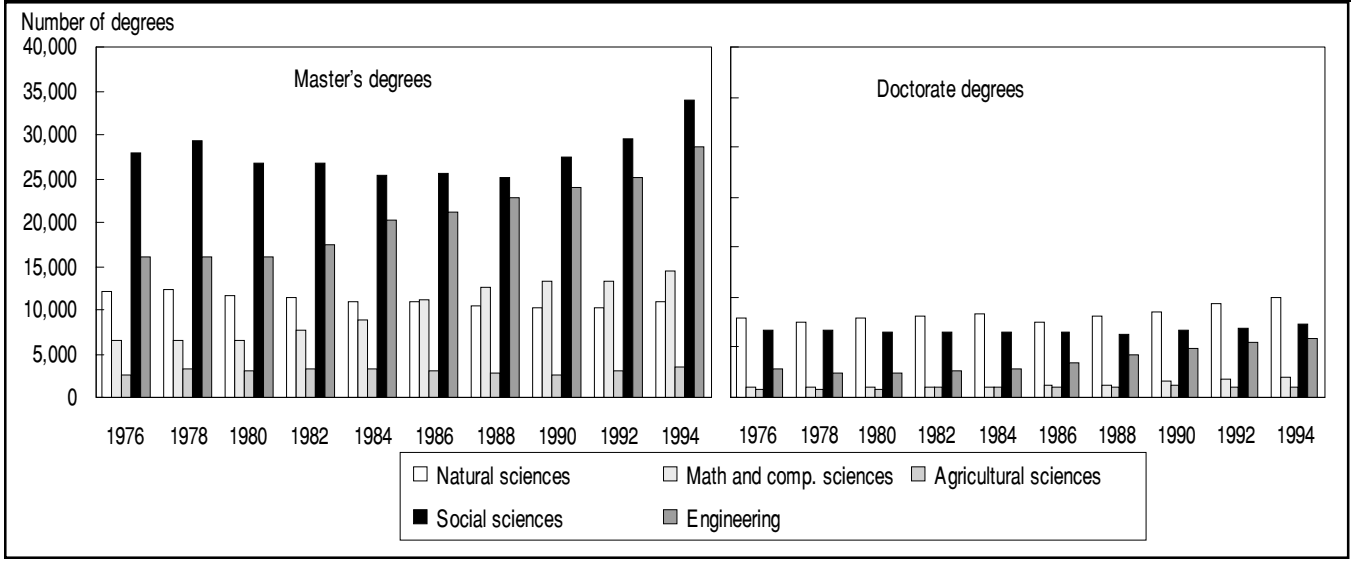


See appendix tables A-19 and A-20.

[20] Includes coursework doctorates, not *ronbun hakase*. The average age for these doctorates, earned by persons employed in industry, is 40-years-old for natural sciences and 42-years-old for engineering.

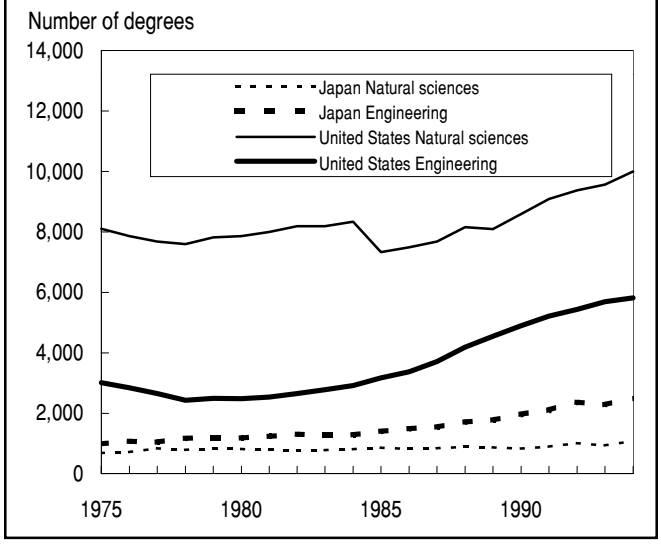
[21] Natural sciences include physical, biological, earth, atmospheric, and oceanographic sciences.

Figure 23. Graduate S&E degrees in United States



See appendix tables A-19 and A-20.

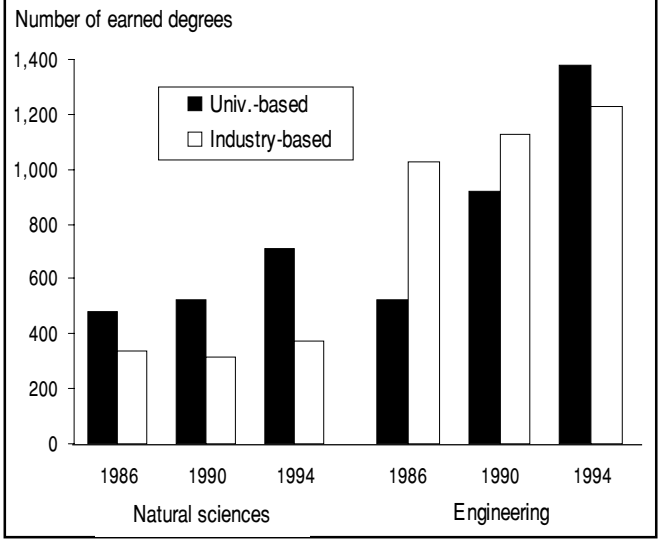
Figure 24. Doctoral degrees in NS&E fields: 1975–94



KEY: NS&E = Natural science and engineering.

See appendix table A-20.

Figure 25. Expansion of Japan's NS&E doctoral degrees



KEY: NS&E = Natural science and engineering.

See appendix table A-20.

Using the better equipped and funded industrial research laboratories for doctoral research training worked very well for Japan during the last several decades of technology development, and likely contributed to their economic success. Japan's technology policy from the 1950s to the 1970s was geared toward large funding of research by industry for adaptive borrowing and quality engineering (Tamura and Peck, 1983). Those familiar with Japan's educational system believe that it has been very well-suited to industrial catch-up, but may not be adequate for the future. Japan now wants to develop the human resources for science and engineering that can create radically new technologies, rather than just adapt and improve on imported technology. In addition, because of their high economic status in the world, international expectations are rising that Japan will apply more of its resources to the kinds of basic research that will have universal benefits (Rohlen, 1995).

A long-discussed shift is occurring toward stronger doctoral programs within university laboratories, with more funding for basic research. Public statements of the need for this shift have been made in Japan for at least the past 25 years. Japan's S&T White Papers since 1973 have emphasized the need to enhance government funding and university basic research to solve new problems that cannot be addressed by off-the-shelf technology (STA, 1973). Initially, these public statements did not change the research picture. Throughout the 1970s and 1980s, industrial research represented an ever-increasing proportion of research. While the amount of government funded research increased slightly, it continued to decline as a percentage of overall research because of the huge industrial research investment.

Financial Support to Graduate Students

Although no national comparative data are available on financial support to graduate students, recent studies show that Japan has traditionally provided little financial support for graduate students. The costs for graduate students in Japan's national universities include a $300 entrance exam, a $3,000 entrance fee, and a $4,500 tuition payment per year. About 26 percent of masters students and 59 percent of doctoral students receive "scholarships" (which are actually interest-free loans that have to be repaid after graduation). Japanese graduate programs provide no tuition waivers for students in science and engineering (Sienko, 1996). In contrast, 70 percent of S&E graduate students in U.S. universities are supported by research assistantships, teaching assistantships, fellowships, and traineeships from federal and university sources (NSB, 1996). Only 30 percent are self-supporting, mainly in the social sciences. In the United States, financial aid includes tuition waivers in a large majority of graduate programs.

Japan is beginning to provide financial aid to graduate students in the form of postgraduate fellowships and research assistantships. Monbusho funds provide assistance to Japanese students, to foreign students for study in Japan, and to Japanese students to study abroad. A small percentage of graduate students (6 percent) receive generous fellowships from the Japan Society for the Promotion of Science (JSPS), similar to the level of support students receive in U.S. graduate schools, to encourage students to proceed up to the doctorate level. New fellowships available in 1996 from JSPS have expanded funding to 1,350 new postdoctorates and doctoral students and have provided 1,750 continuing awards from the previous year. By 1996, about 6,000 Japanese graduate students and postdoctorates had some government funds. The target is to fund about 10,000 government fellowships (JSPS, JST, and NEDO) by the year 2000.

In contrast, in the United States, in 1993, 45,000 graduate students received their primary support from fellowships and traineeships, and another 155,000 were supported primarily through research assistantships and teaching assistantships (NSB, 1996).

Foreign Students in Graduate Programs

The majority of foreign students in Japan are at the undergraduate level. Only 17,800 out of 50,000 foreign students are studying at the graduate level. In contrast, in the United States, almost one-half of the 425,000 foreign students are studying at the graduate level. Of the approximately 191,800 who come to the United States for graduate studies, about one-half are in the natural sciences and engineering fields. Likewise, more than one-half of the foreign graduate students in Japan are in S&E fields (table 10).

Table 10. Foreign students in S&E graduate programs: 1994

Field of study	Japan		United States	
	[Number]	[Percent]	[Number]	[Percent]
Total	17,801	100.0%	191,798	100.0%
S&E fields	10,127	56.9	96,475	50.3
Natural sciences	852	4.8	29,153	15.2
Agricultural sciences	1,559	8.8	5,562	2.9
Social Sciences	2,967	16.7	17,645	9.2
Engineering	4,749	26.7	44,114	23.0
Other fields	7,674	43.1	95,324	49.7

SOURCES: Government of Japan, Monbusho, unpublished tabulations; Institute of International Education, *Open Doors, 1994–95* (IIE: New York, 1995), and unpublished tabulations.

Among the leading countries of origin of foreign graduate students in Japan are China and Korea, comprising almost three-quarters of the 17,800 foreign graduate students present in 1994. Most other leading countries of origin also are within the Asian region. The leading countries of origin of foreign graduate students in the United States are China and India, comprising one-third of the total foreign graduate students present (table 11).

Table 11. Leading countries of origin of foreign students in graduate programs: 1994

Country of origin	Japan		United States	
	[Number]	[Percent]	[Number]	[Percent]
Total	17,801	100.0%	191,738	100.0%
China	9,152	51.4	36,370	19.0
Korea	4,003	22.5	27,553	14.4
Indonesia	642	3.6	24,623	12.8
Bangladesh	461	2.6	15,785	8.2
Thailand	460	2.6	7,755	4.0
Other	3,083	17.3	79,652	41.5

SOURCES: Government of Japan, Monbusho, unpublished tabulations; Institute of International Education, *Open Doors, 1994–95* (IIE: New York, 1995), and unpublished tabulations.

Foreign students comprise only 8 percent of the total graduate enrollment in the natural sciences in Japanese universities, and they account for only 10 percent of the engineering students. They are concentrated at the doctoral level, however, and are contributing to the expansion of doctoral programs and degrees in Japanese universities. In 1992, 37% of the engineering doctoral degrees were earned by foreign students; 25% of the natural science doctoral degrees were earned by foreign students in the same year. In contrast, in U.S. universities, slightly more than 50 percent of the engineering doctoral degrees and one-third of the natural science doctoral degrees were earned by foreign students in 1993.

Foreign doctoral recipients have increased at the annual rate of 13 percent from 1987–92. For this number to double, from approximately 1,000 in 1992 to 2,000 in the year 2000, would require sustaining an annual growth rate of 12 percent. This would be possible, but only likely if financial support to foreign doctoral students also continued to increase.

Graduate students from the United States account for only 1 percent of the foreign graduate students in Japan, and relatively few of them are in S&E programs requiring university research laboratories. A few dozen American graduate students are studying for their master's degrees in engineering within Japanese universities while only a few Americans are studying natural sciences within Japanese universities. In contrast, Japan is one of the leading countries of origin for foreign students and foreign researchers in U.S. universities and also for visiting scientists at U.S. laboratories. In 1993–94, the numbers of students and researchers from Japan reached almost 50,000. About 40,000 are students, and 10,000 are conducting research (table 12).

Table 12. Japanese foreign students and visiting researchers to the United States: 1993–94

Category	Number
Total	49,578
Students	39,715
Undergraduate	31,960
Graduate	7,755
Researchers	9,863
Post-doctorate/U.S. univ	4,055
Foreign scholars/U.S. univ	5,458
Visiting scientists/NIH 1/	350

1/ NIH has the largest visiting scientists program, but other U.S. government agencies also receive visiting scientists from Japan.

NOTE: Researchers are based mainly on estimates for post-doctorates and foreign scholars in *Open Doors, 1994–95.*

SOURCE: Institute of International Education, *Open Doors, 1994–95* (IIE: New York, 1996).

Of the Japanese foreign students coming to the United States, the large majority (80 percent) enter undergraduate programs for non-S&E fields of study. The most popular fields in which they major are business and economics. The attraction to U.S. higher education is partially attributable to stiff competition for admission to the prestigious Japanese national universities. Many Japanese students who do not pass the qualifying examinations for these top schools have opted for U.S. undergraduate education because the less-competitive Japanese private schools, their other option, are costly and crowded. Relatively few of the Japanese students in U.S. undergraduate programs (6 percent) study natural sciences or engineering.

A far smaller number of Japanese foreign students enter U.S. graduate programs, and only a small fraction of these study the fields of science and engineering. Traditionally, relatively few Japanese entered lengthy doctoral programs of science or engineering in U.S. universities. However, similar to the recent increase in S&E doctoral degrees within Japanese universities, the number of degrees earned by Japanese students in the U.S. universities is also increasing. In 1994, Japanese foreign students earned 46 doctoral degrees in engineering and 136 doctoral degrees in all fields of science, similar to the number earned by foreign students from other industrialized nations, such as Germany (NSF, 1996b).